

Control of Alternaria Blight of Ginseng With Bordeaux Mixture and Injuries Accompanying Its Use

H. A. Runnels and J. D. Wilson



OHIO
AGRICULTURAL EXPERIMENT STATION
Wooster, Ohio



The Ohio State University
3 6267 01222021 9

This page intentionally blank.

CONTENTS

Recommendations	2
Introduction	3
Description of the Disease	4
Spray Materials and Schedule	6
Results and Discussion	7
Spray Injury	10
Preparation of the Spray Material	13
Summary and Conclusions	13
Literature Cited	16

RECOMMENDATIONS

1. Select a site with good air circulation and soil drainage as an aid to the ginseng plant in resisting disease.

2. Do not crowd the plants too closely together in the beds.

3. Follow a definite spray program, timing the application of the sprays as follows: (a) Just as the plants are coming up (if they appear unevenly, apply two sprays about 1 week apart); (b) just after the leaves are fully expanded; (c) a few days before bloom; (d) shortly after the fruits are well set.

4. Use a 3-4½-50 bordeaux mixture to which 1 pint of potash fish-oil soap and 1 pound of calcium arsenate have been added for each 50 gallons of spray.

5. Be careful to cover thoroughly the stems of the plants, as well as the leaves, with the spray material. This is especially important with the first application (applied just as the plants are coming up), because the stems are very susceptible to infection at this time.

6. In the case of woodlot plantings, avoid the application of bordeaux mixture to the plants at any time when they are obviously suffering from a lack of soil moisture, or else water the beds artificially before spraying.

7. Carefully destroy all diseased ginseng tops after they die down in the fall. This may be done in any one of the following ways: (1) By first removing all diseased material from the beds and then burning or burying it, (2) by covering the beds with straw and then burning it in place, or (3) by burning the diseased material from the beds with a kerosene torch.

8. If *Alternaria* blight is especially troublesome, the additional precaution may be taken of spraying the beds in the fall after they are burned with a solution of copper sulfate in water. Dissolve 1 pound of copper sulfate in 7½ gallons of water and apply enough of the liquid to wet the soil to a depth of ½ inch.

9. If seeds or roots from beds known to have been severely affected with *Alternaria* blight are to be planted, it is advisable to immerse them for 10 minutes in a 1-75 solution of formaldehyde in water. At the end of this 10-minute period the seed or roots should be removed and rinsed thoroughly with water immediately.

CONTROL OF ALTERNARIA BLIGHT OF GINSENG WITH BORDEAUX MIXTURE AND INJURIES ACCOMPANYING ITS USE

H. A. RUNNELS AND J. D. WILSON

INTRODUCTION

Ginseng (*Panax quinquefolium* L.), which is native to Ohio, is found most commonly on well-drained, wooded slopes. It has been so widely collected for its roots during the past 50 years that it has now been reduced nearly to the vanishing point in its natural habitats. Cultivated plantings were started about 40 years ago at various places in the State. The number of these gardens has since increased until there are now a great many of them widely scattered over Ohio. The majority of these are, however, located in the north-eastern quarter of the State where a large percentage of the crop is grown in carefully selected woodlots.

In growing ginseng, a shade-loving plant, it is important that an evenly distributed shade (one-fourth normal light intensity) be provided (2)¹. In woodlot plantings this is best furnished by large, open-headed trees in a thin but even stand. There should be an absence of underbrush to facilitate air circulation and rapid drying of the leaves of the plants after rains or wet periods. In woodlot sites the natural soil drainage should be good. If lath shelters are used tile drainage should be provided, since ginseng does not thrive in soils with continuously high water content. Poor air circulation and a high soil-moisture content both favor the attack of the plants by most of the diseases to which ginseng is subject.

One of the most widespread and destructive diseases of ginseng is known as Alternaria blight, caused by *Alternaria panax* Whetzel. This disease has been present in commercial gardens for about 30 years (6)². It is thought to have occurred on plants growing in their natural habitat in the forest before it made its appearance in cultivated plantings (5).

After the fungus causing this disease once obtains a foothold in a commercial garden, it does not subsequently entirely die out. The severity of the disease during any following year will be chiefly regulated by the weather conditions. Long periods of wet weather are particularly favorable to the spread of the disease; whereas it is checked by extended dry periods.

The crowded condition of the plants under cultivation is very favorable to the development of Alternaria blight, and, as a result, it often reaches epidemic proportions (whole gardens being practically defoliated) where proper control measures are not employed. Since the ginseng roots are harvested when about 5 to 7 years old, premature defoliation in any one year, even though it may occur early in the summer, is not usually fatal to the existence of the plant. However, if early defoliation occurs consistently year after year because of

¹U. S. Dept. Agr., Farmers' Bull. 1184 should be consulted for detailed information on ginseng culture.

²U. S. Dept. Agr., Farmers' Bull. 736 includes descriptions of several ginseng diseases with recommendations for their control. These Farmers' Bulletins may be obtained, for a small charge, from the Superintendent of Documents, Washington, D. C.

the attack of disease or the occurrence of severe drouth, the roots do not attain normal size and the final yield will be greatly reduced. Whetzel (6) has estimated that the reduction in yield of mature roots, due to the attack of *Alternaria* blight alone, may be as great as 50 per cent.

In spite of the fact that bordeaux mixture has been recommended for years as a preventive measure in combating this disease (5, 6), many of the ginseng growers in Ohio have not made the best use of the information; because of this, some of them have suffered severe losses during recent years. In this bulletin are reported the results of several years' experiments in spraying ginseng, carried on in an effort to determine the relative merits of different spray materials for the control of *Alternaria* blight of ginseng.

DESCRIPTION OF THE DISEASE

Although the grower frequently first becomes aware of the presence of this disease in his garden in the spring when he notices the conspicuous lesions on the leaves, the chances are that it has been present on the stems of the plants for 2 or 3 weeks. The young stems, as they are coming through the

soil, are very susceptible to attack by the *Alternaria* fungus. The first visible evidence that infection of the stem has taken place is the appearance, soon after the plants are well up, of an elongated, brownish lesion on one side of the stem, usually near the soil surface. These areas enlarge rapidly for a time and then assume a finely granular, velvety appearance. This indicates that spore production by the fungus, which has been growing and spreading through the stem tissue, has begun. These spores, by means of which the disease is spread, are scattered about the nearby surroundings by the wind and splashing raindrops. During certain kinds of weather (damp or rainy periods continuing for about 24 hours), the spores which fall on ginseng plants are capable of causing infection, particularly of the

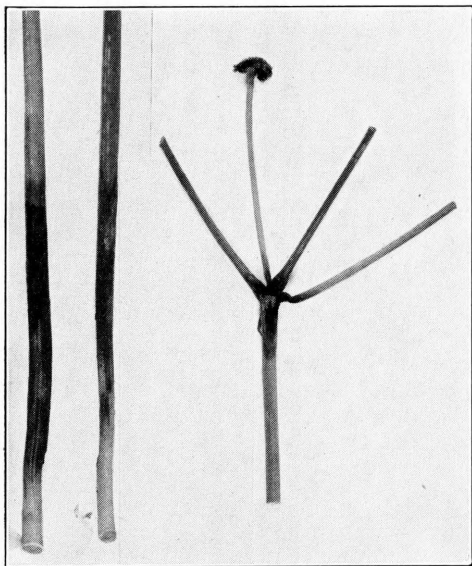


Fig. 1.—*Alternaria* blight lesions on stems of ginseng. Note the jet-black areas indicating the presence of spores of the causal organism.

leaves and fruit clusters. New lesions appear about 7 to 10 days after infection. This process of spore production and infection may be repeated several times during the growing season.

The lesions, which occur near the base of the stem, usually develop rapidly and often completely encircle it (see stems in left-hand portion of Figure 1). The diseased tissue frequently becomes so shriveled and weakened that the

plant topples over. The leaves of the plants which have well-developed lesions on their stems often turn yellow or red, thus helping to distinguish these plants from their more healthy neighbors. This symptom, however, is not specific to *Alternaria* blight alone, since other forms of injury may result in a similar reaction by the plant. Infection of the stem may occur at other places, as at the point where it branches to form the primary petioles (see right-hand portion of Figure 1). When a lesion develops at this point, the petioles usually collapse, allowing the leaves to fall and hang down against the stem in a manner characteristic of this disease. Infection of the seed head frequently occurs, involving the top of the peduncle, the pedicels bearing the berries, and the berries themselves. Infection at this point results in a blackening, shriveling, and shelling of the seeds. Leaf infection results in the formation of

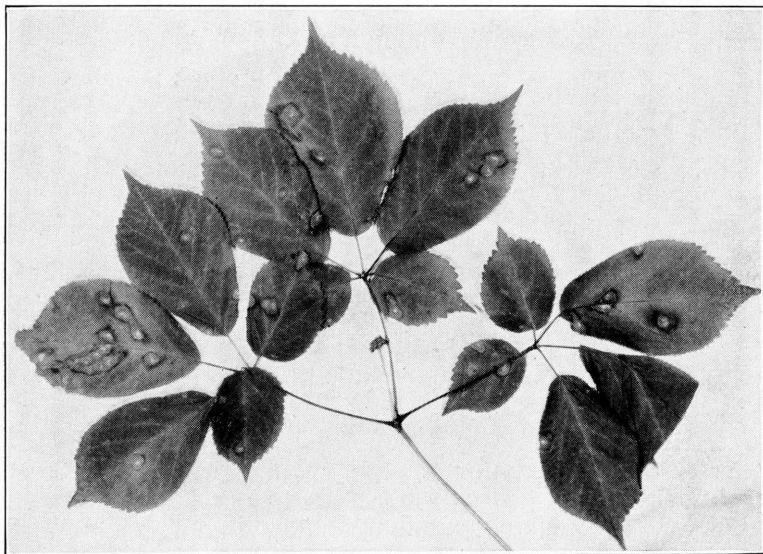


Fig. 2.—*Alternaria* blight lesions on leaves of ginseng. Note papery centers and dark-colored borders (actually reddish-brown)

lesions which, as mentioned above, constitute the most conspicuous manifestation of the presence of *Alternaria* blight in the ginseng bed. The appearance of small, water-soaked areas is the first visible symptom of the disease on the leaves. These spots enlarge until some of them reach a diameter of one-half inch or even more. Where several spots occur on one leaflet it is often killed. The diseased tissue soon begins to dry out at the center of the lesion and takes on a whitish, papery appearance. This is illustrated in Figure 2, which shows a ginseng plant in an early stage of the disease on the leaves. The advancing borders of the lesions are reddish-brown in color, as indicated by the dark ring around those lesions shown on the leaflet to the extreme right in Figure 2. Spores are seldom, if ever, produced from the lesions on the leaves; whereas they are produced on practically all stem lesions.

The roots of the ginseng plant are also subject to attack by the *Alternaria* blight fungus. However, this occurs with comparative rarity, and then only

those roots which have been injured previously, in some manner, are affected. The attack on the roots is manifested by the slow advance of a dry, brownish rot.

The causal organism of ginseng blight (*Alternaria panax*) lives over the winter in a dormant, vegetative condition (as mycelium) in diseased ginseng tissue. With the advent of spring the fungus resumes growth and soon produces spores. These are usually developed sufficiently to be capable of causing infection of the young ginseng shoots by the time the latter are through the soil. It is likely that some of the spores produced in the fall live through the winter in the soil of the ginseng bed and on the seed. Just how important these are as sources of infective material the following spring is not known by the authors.

The fact that the diseased crop refuse is the most important medium concerned in the survival of the fungus over the winter emphasizes the importance of destroying as much of this material as possible in the fall. This can be accomplished by burning the diseased tops from the beds in the late fall with a kerosene weed burner or by covering the beds with straw and burning this in place. Another recommendation which is sometimes made to reduce the source of infection is that of wetting the surface of the bed to a depth of about one-half inch with a copper sulfate solution, prepared by dissolving 1 pound of copper sulfate in $7\frac{1}{2}$ gallons of water. If seeds or seedling roots from beds in which *Alternaria* blight was known to have been severe are to be planted, it is advisable to immerse them for 10 minutes in a 1-75 solution of formaldehyde in water. At the end of this 10-minute interval they should be removed and thoroughly rinsed in water immediately.

SPRAY MATERIALS AND SCHEDULE

As mentioned above, bordeaux mixture has been recommended for years for the control of *Alternaria* blight of ginseng (5). The most popular formula has been a 3-3-50 (or a 3-4½-50 if hydrated lime is used). The addition of an arsenate, particularly calcium arsenate, to this formula has also been recommended (4). During the past 5 years the authors have used a variety of sprays and dusts in experiments on the control of *Alternaria* blight. These have included such materials as 3-4½-50 bordeaux mixture, used alone and in combination with various stickers, spreaders, and arsenical compounds. In addition, Pyrox (a proprietary mixture), colloidal copper sulfide, colloidal sulfur, and a monohydrated copper-hydrated lime dust have been used (1, 7, 8).

A definite spray schedule was followed which included four sprays applied at particular growth stages in the seasonal development of the ginseng plant; namely, (1) as the plants were coming up (as soon as most of them had broken through the surface of the soil), (2) when the leaves on all of the plants were fully expanded, (3) just preceding bloom, and (4) about 2 to 3 weeks later when the fruits were well formed. Care was exercised to secure thorough coverage of the stems and petioles, especially early in the season when these parts are very susceptible to infection. The spray materials were applied with a portable hand sprayer of the wheelbarrow type.

RESULTS AND DISCUSSION

Following several severe outbreaks of *Alternaria* blight in previous seasons, the authors began some preliminary experiments on its control in the spring of 1928. One year was devoted to preliminary experimentation with a variety of materials. Monohydrated copper-hydrated lime dust which had given fair control of various similar leaf-spot diseases on other crops was first being used on ginseng in Ohio at about this time. Accordingly, this material, bordeaux mixture, and three other copper-containing sprays were included in this first experiment.

Ginseng, which possesses a comparatively thin and tender leaf, is rather sensitive to spray injury. This is especially true of the new foliage in the spring. For this reason a strong bordeaux mixture (high in copper and lime) cannot be used on it to advantage for disease control, and, consequently, the 3-4½-50 formula has been generally accepted. Bordeaux mixture, as well as many other spray materials, does not spread on or adhere to the ginseng plant as well as might be hoped for. Accordingly, potash fish-oil soap, which acts both as a spreader and sticker, was added to the bordeaux mixture and this was then compared with the standard formula. Kurtakol and colloidal copper sulfide, in each of which the copper exists in a colloidal state, were included in this first experiment because of the possibility that they might give control of ginseng blight. Ammoniacal copper carbonate, which is prepared by dissolving copper carbonate in ammonia, was also included.

Copper-lime dust applied to plants in the open field depends for its efficiency in disease control upon intimate association with water. If this material is to give the best results, it should be applied to the plants while they are moist so that the reaction between the copper and lime may take place immediately before the hydrated lime has time to become carbonated in contact with the air. Dew is very seldom formed in any appreciable quantity on ginseng plants in woodlot plantings because they are growing on the forest floor with a canopy of leaves above. Hence, a copper-lime dust applied to ginseng growing in a woodlot is robbed of a great deal of its fungicidal effectiveness, because there is seldom sufficient water present to insure the occurrence of the necessary chemical changes. In the results given in Tables 1 and 2 it will be observed that this material has not proved to be effective in the control of *Alternaria* blight. In order to insure the presence of sufficient water on the leaves to bring about the formation of bordeaux mixture when they were treated with copper-lime dust, the plants in one of the plots selected for dusting were sprayed with water just before the dust was applied.

The plants were treated with these different compounds at four different times during the season according to the spray schedule outlined in the preceding section of this bulletin. The results are shown in Table 1.

Kurtakol, colloidal copper sulfide, and ammoniacal copper carbonate failed to give control of *Alternaria* blight. Likewise, the copper-lime dust treatments were not very effective. Wetting the plants with water just previous to dusting increased the degree of control but still failed to give the results desired; in any event, this method would be of little practical value because two operations are involved in treating the plants. The use of kaolin (clay) to replace part of the lime decreased the efficiency of the treatment, and increasing the ratio of copper to lime in the dust did not significantly improve its fungicidal efficiency in this instance. The 3-4½-50 bordeaux mixture gave

much better control of ginseng blight than any of the other materials included in this experiment. The addition of 1 pint of potash fish-oil soap to each 50 gallons of spray material slightly increased the degree of control.

TABLE 1.—Efficiency of Different Fungicidal Preparations in Controlling Ginseng Blight in Preliminary Experiments of 1928

Treatments	Percentage of plants diseased
No treatment.....	77
Sprays:	
Kurtakol, 4 lb.—50 gal.....	75
Colloidal copper sulfide, 4 lb.—50 gal.....	60
Ammoniacal copper carbonate (Copper carbonate, 3 oz. + 3 pints ammonia—50 gal.).....	70
Bordeaux mixture, 3-4½-50.....	7
Bordeaux mixture, 3-4½-50, plus potash fish-oil soap, 1 pint—50 gal.....	4
Dusts:	
Copper-lime, 20-80 (plants dry).....	55
Copper-lime, 20-80 (plants wetted).....	30
Copper-kaolin-lime, 20-30-50.....	60
Copper-lime, 35-65.....	45

In the spring of 1929, areas in two different woodlot plantings containing several very similar beds of seedling ginseng plants were reserved for the purpose of carrying on a spraying experiment to extend over a period of 4 or 5 years. A given bed was to receive the same treatment each year until the plants had reached maturity. At the end of this period the roots were to be harvested and weighed. The plots were treated as follows: (1) No treatment; (2) 20-80 copper-lime dust; (3) colloidal copper sulfide, 4 pounds to 50 gallons; (4) bordeaux mixture, 3-4½-50; (5) Number 4 plus aluminium hydrate, 1 pound to 50 gallons; (6) Number 4 plus potash fish-oil soap, 1 pint to 50 gallons; (7) Number 6 plus arsenate of lead, 1 pound to 50 gallons; and (8) Number 6 plus manganar (a proprietary manganese arsenate), 1 pound to 50 gallons. At the beginning of the second year a plot was added to receive Pyrox (a proprietary bordeaux mixture containing arsenates), 10 pounds to 50 gallons. At the beginning of the third year two more plots were included—one to receive colloidal sulfur, 1 pound to 50 gallons plus 6 ounces of dried skimmed milk, and the other to receive Number 6 above plus calcium arsenate, 1 pound to 50 gallons.

The plants were treated with the sprays listed in the preceding paragraph through the seasons of 1929, 1930, 1931, and 1932. Four applications were made each year according to the schedule outlined in a previous section of this bulletin. The effectiveness of the various treatments in controlling *Alternaria* blight of ginseng is shown in Table 2, where the results are given as the percentages of plants in each bed which were affected by the disease at the end of the season.

Ginseng blight was very severe in both of the woodlots in which this experiment was being carried on during the years of 1929, 1931, and 1932, as is indicated in Table 2 by the high percentage of diseased plants in the plot receiving no treatment. In the summer of 1930, the disease hardly reached epidemic proportions, due largely to the onset of hot, dry weather about the middle of June. As was the case in 1928, copper-lime dust did not give control of *Alternaria* blight and colloidal copper sulfide was but little better. The

3-4½-50 bordeaux mixture used alone gave very satisfactory control during 3 of the 4 years, but a great deal of infection appeared in the bed treated with it in 1931. It is thought by the authors that the poor results obtained with all of the spray preparations in 1931 were probably due to the fact that the timing of the sprays did not give the plants the proper protection against the disease during this particular year. In the spring of this year the first application of the sprays was not made until most of the plants had reached an upright position, and, as a result, early infection was more severe than in the other seasons. The addition of aluminium hydrate to the bordeaux mixture did not increase its effectiveness. The addition of fish-oil soap to bordeaux mixture has been recommended for years to improve its spreading and sticking properties. It was found that in spraying ginseng, a plant which at best is rather difficult to cover thoroughly, the addition of soap greatly aided in securing good coverage with a minimum amount of material and effort. This alone made its use worth while, even though the control obtained was not significantly better than with bordeaux mixture alone. The addition of various arsenates to the bordeaux-soap mixture increased the effectiveness of the spray in nearly

TABLE 2.—Effect of Various Spray Materials in Controlling Alternaria Blight of Ginseng, 1929-1932 Inclusive. Percentage of Disease

Treatments	1929	1930	1931	1932	4-year average, 1929-1932	2-year average, 1931-1932
1. No treatment.....	86.4	24.2	99.4	100.0	77.5	99.7
2. Copper-lime dust, 20-80.....	84.0	29.2	100.0	100.0	78.3	100.0
3. Colloidal copper sulfide, 4 lb.—50 gal.	63.7	29.8	99.6	100.0	73.3	99.8
4. Bordeaux mixture, 3-4½-50.....	2.3	3.2	90.6	8.5	26.2	49.6
5. No. 4 + aluminium hydrate, 1 lb.—50 gal.....	2.3	8.6	82.6	13.3	26.7	48.0
6. No. 4 + potash fish-oil soap, 1 pint—50 gal.....	2.1	2.8	89.3	7.8	25.5	48.5
7. No. 6 + arsenate of lead, 1 lb.—50 gal.....	1.7	3.2	49.2	14.0	17.2	31.6
8. No. 6 + manganar, 1 lb.—50 gal.....	1.6	3.3	32.0	12.4	12.3	22.2
9. No. 6 + arsenate of calcium, 1 lb.—50 gal.....	.....	.....	50.0	5.2	.....	27.6
10. Pyrox, 10 lb.—50 gal.....	.....	3.4	81.6	15.6	.....	48.6
11. Colloidal sulfur, 1 lb.—50 gal. + 6 oz. dried, skimmed milk.....	.....	.....	60.0	100.0	.....	80.0

every instance, particularly in 1931. The relative effectiveness of the lead, calcium, or manganese arsenates is rather difficult to determine from the data given in Table 2. Manganese arsenate gave good results in 1931, but it was not as good as calcium arsenate in 1932 and was not significantly better than lead arsenate in 1929 and 1930. Whetzel (4), as mentioned previously, found calcium arsenate to be very toxic to the spores of the Alternaria blight fungus, and, since this material is usually cheaper than either lead arsenate or manganar, it seems reasonable to recommend its use with bordeaux mixture in spraying ginseng for Alternaria blight control. Pyrox, used at the rate of 10 pounds to 50 gallons of water, did not give significantly better control in these experiments than a 3-4½-50 bordeaux mixture used alone or with soap and was not as good as the latter mixture plus any one of the arsenates mentioned in Table 2. If the grower does not wish to prepare his own bordeaux mixture, Pyrox may be used as a substitute, but its cost is considerably greater. Colloidal sulfur plus dried, skimmed milk gave no control of ginseng blight when used at the rate of 1 pound to 50 gallons. Some control was obtained by doubling this concentration, but the spray injured the plants.

The beds which had received the treatments enumerated in Table 2 were harvested in the fall of 1932. At the time the experiment was started in 1929, it had been thought that the weight of the roots obtained from each differently treated bed at the end of the experiment would provide supplementary data to those obtained from the tops and thus would aid in determining the relative effectiveness of the different spray materials to be used. However, two sources of error entered into the experiment before its conclusion which seriously affected these yield data. Various and widely differing numbers of roots in the different beds included in the experiment were attacked and destroyed by the black-rot fungus (*Sclerotinia smilacina* Dur.). Also, as will be discussed in the next section of this bulletin, the beds treated with any of the sprays containing bordeaux mixture had been either entirely or partially defoliated before the end of the 4 years over which the experiment had continued; whereas the remaining beds had not been subjected to this stunting effect. These two unequally distributed influences affected the growth of the roots in the various beds so differently that variations in the yields obtained were not considered to be significant, and, consequently, the data are not considered here.

SPRAY INJURY

Injuries resulting from the application of bordeaux mixture to ginseng are principally of three different kinds: 1. When bordeaux mixture is improperly prepared (too high in copper or too low in lime) or is used in too great a concentration, leaf burning may result. This injury usually progresses inward from the margin of the leaflet. Only the marginal tissue may be affected, or the whole leaflet may dry up and die. 2. The plants are particularly susceptible to injury just as they are coming up in the spring. This is frequently a period of rather cool weather with occasional frosts. If a heavy frost occurs just following a spray application, severe injury may result (3). Following this type of injury, the leaves are water-soaked and appear as if scalded. As they dry out later they become papery and brittle. If this combination of bordeaux and cold injury is not too severe, only the margins of the leaflets are affected and as they grow the margins become imperfect, with

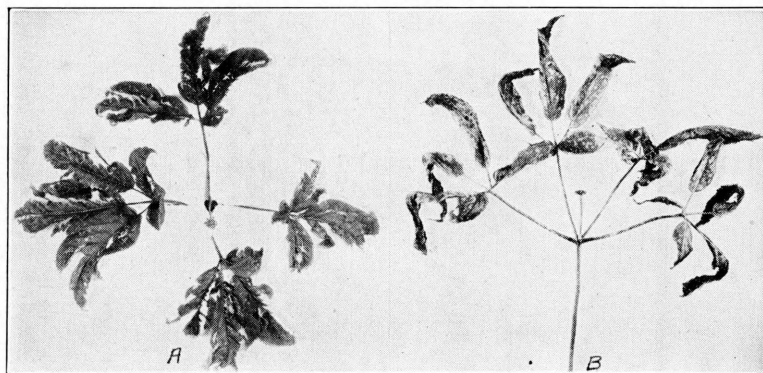


Fig. 3.—A. Combination bordeaux mixture-cold weather injury occurring on ginseng shoots in early spring. B. Combination bordeaux mixture-drought injury

deep irregularities. The body of the leaflet is often very wrinkled with gaps in the tissue, as is shown in Figure 3A. 3. When plants which have been sprayed with bordeaux mixture begin to suffer from a lack of soil moisture at the beginning of a drouth period, the leaflets finally begin to wilt and droop. If a rain does not soon intervene, this condition is quickly followed by marginal burning. The affected tissue first takes on a darkened and rather water-soaked appearance and then rapidly dries out, without entirely losing its green color. The leaflets soon become wrinkled and crisp, the tissue near the midrib being the last to die. Figure 3B represents a plant in this stage of bordeaux-drouth injury. Complete defoliation usually takes place within 2 or 3 weeks.

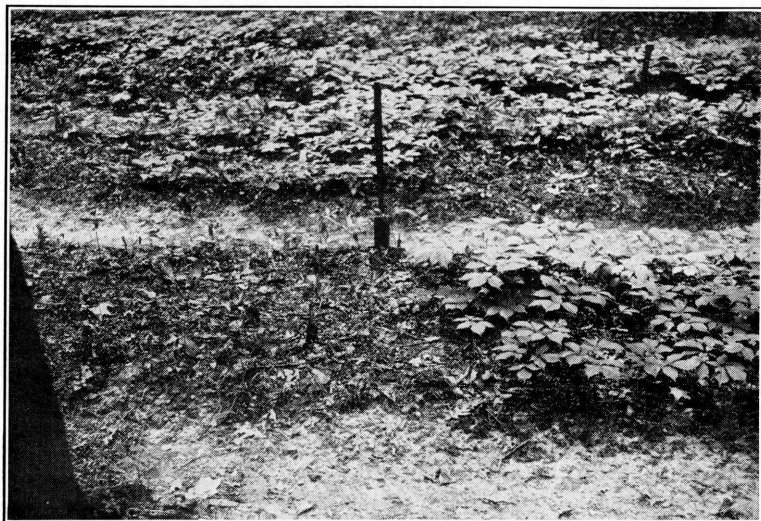


Fig. 4.—Bordeaux mixture-drouth injury on ginseng. Plants to left of stake sprayed with bordeaux mixture; those to the right sprayed with colloidal copper sulfide

During the last 3 of the 5 years involved in this experimentation, the moisture content of the soil in the woodlots in which these spraying experiments were being conducted became low enough so that the type of drouth injury discussed above occurred. It finally became very marked during the extremely severe and prolonged drouth of 1930. By the end of July practically all of the plants growing in woodlots which had been sprayed with bordeaux mixture were defoliated. In one of the woodlots most of the plants which had been sprayed with bordeaux mixture, either by the authors or the growers, were severely injured by drouth by the end of June. However, with the exception of the few plants which were affected with *Alternaria* blight, the check plots and those which had received sprays other than bordeaux mixture remained normal in appearance until the end of the growing season (9). This condition is illustrated in Figure 4, in which the bed shown on the left, with the plants completely defoliated, had been sprayed earlier in the season with bordeaux mixture; whereas the one on the right, where the plants appear normal, was sprayed with colloidal copper sulfide (a spray material which does not appreciably increase the rate of plant water loss).

Many of the observations made during the progress of the 1930 drouth convinced the authors that some very definite relationship must exist between the presence of the bordeaux film on the leaves of the ginseng plant and the onset and severity of the drouth injury which occurred with the lowering of the soil-moisture content (9). Accordingly, during the summers of 1931 and 1932, a variety of experiments was carried on to determine the influence of bordeaux mixture on the rate of water loss of plants, with particular reference to the response of plants growing in soils held at low moisture contents. It was found that bordeaux mixture does increase the transpiration rate of most plants to which it is applied and that, when plants suffering from a lack of soil moisture are sprayed with this material, injury occurs which may grade from mere stunting of growth to complete tissue desiccation, accompanied by defoliation and death (10).

During the summer of 1931, drouth again became severe enough so that defoliation of plants which had been sprayed with bordeaux mixture began to take place in restricted areas which, because of their location near large trees or at the top of slight slopes, were obviously low in soil moisture. These areas of drouth injury increased in size until they came to occupy approximately one-half of the total area of the woodlot mentioned above before the drouth condition was relieved by rain. During this period of advancing injury, determinations were made of the soil-moisture content of areas in which the plants had just begun to show drouth injury and in closely adjacent ones where the plants still appeared normal. The moisture contents were 12 and 17.5 per cent, respectively, computed on the basis of the dry weight of the soil (1). These results indicate that, in the silt loam soil of this woodlot, the critical soil-moisture content for the occurrence of drouth injury to ginseng plants sprayed with bordeaux mixture lies somewhere between the values mentioned above. During the summer of 1932, drouth conditions again became severe enough so that bordeaux-drouth injury affected the ginseng plants in at least half the total area included in the woodlot mentioned above. The grower was forced to omit the application of the last spray from the plants growing in certain very dry areas in the woodlot when it was found that the spraying of plants which were already on the verge of wilting, because of the low soil-moisture content prevailing, caused the leaflets to collapse almost immediately and to dry up and die within a day or two.

The series of observations mentioned above, in which the occurrence of very similar environmental conditions brought forth similar responses by the ginseng plant, indicates very clearly that great care should be observed in spraying ginseng with bordeaux mixture during periods of severe drouth. This is especially true of woodlot plantings. If artificial irrigation can be provided, it would seem likely that no interruption in the regular spray schedule need take place. Although it is generally recommended that the application of fungicidal material to plants should precede rather than follow rainy periods if the best disease control is to be obtained, it might be well worth while to put off spraying ginseng until after the occurrence of a rain heavy enough to increase the soil-moisture content to a point near the optimum, if the plants are known to be suffering from a lack of soil moisture at the time when they should be sprayed according to a schedule based upon their growth stage. This warning may, of course, usually be disregarded in the spraying of plants grown in lath shelters, since they are seldom subjected to the extreme deficiencies of soil moisture described above for woodlot plantings.

PREPARATION OF THE SPRAY MATERIAL

To make 50 gallons of a 3-4½-50 bordeaux mixture proceed as follows:

- (1) Entirely dissolve 3 pounds of copper sulfate in about 3 gallons of water;
- (2) thoroughly mix 4½ pounds of hydrated lime with 2 or 3 gallons of water and dilute this mixture with about 30 to 35 gallons of water in the spray tank;
- (3) pour the copper sulfate solution *into* the water-lime mixture with vigorous stirring of the combining materials;
- (4) mix 1 pound of calcium arsenate with about 1 gallon of water and stir the resulting paste into the larger volume of bordeaux mixture;
- (5) dilute 1 pint of potash fish-oil soap with at least 1 gallon of water and, in turn, add this also to the bordeaux-arsenate mixture;
- (6) add sufficient water to make 50 gallons of spray material.

To make 10 gallons of this spray material (sufficient to fill the tank on a wheelbarrow sprayer) use 10 ounces of copper sulfate, 15 ounces of hydrated lime, 3 ounces of calcium arsenate, and about 3 ounces of soap. Follow the same procedure given above for mixing the various materials, adjusting the amounts of water to obtain finally a 10-gallon quantity of spray material. If it is desired to make only the 3 gallons necessary to fill a knapsack type of sprayer, the following quantities of each ingredient should be used: 3 ounces of copper sulfate, 4½ ounces of hydrated lime, 1 ounce (4 level tablespoonfuls) of calcium arsenate, and 1 ounce (2 tablespoonfuls) of soap.

Small quantities of bordeaux mixture may be prepared more easily and quickly by the use of a product known as "snow" copper sulfate, in which crystals of the ordinary size have been broken up into much smaller units. These fine crystals may be very quickly dissolved in water, a process which is sometimes very tedious with large crystals and cold water. It is also important to use fresh (from a recently opened container) hydrated lime since a part of this material soon becomes "carbonated" in contact with the air and then will not make a high quality bordeaux mixture.

SUMMARY AND CONCLUSIONS

Ginseng (*Panax quinquefolium* L.), a plant native to Ohio, has nearly disappeared from its natural habitats because it has been widely collected for its roots. Cultivated plantings were started in Ohio about 40 years ago. It is now grown both under lath shelters and in woodlots. Sites must be carefully chosen for good air and soil drainage.

Alternaria blight (*Alternaria panax* Whetzel) is now the most serious disease of ginseng in Ohio. It has been present in commercial plantings for at least a quarter of a century, where the crowded condition of the plants is very favorable to its occurrence in epidemic proportions. The disease is favored by periods of warm, wet weather and hindered by dry, cool conditions.

Although severe attacks of Alternaria blight may defoliate the plants, they are not usually killed from this cause alone but only stunted. Repeated attacks during the 5 or 6 years required for the crop to reach maturity may cut the final yield in half. Any part of the plant may be attacked by the disease. Early infection usually occurs on the young stems, where elongated, dark-colored lesions often so weaken the tissue that the plant topples over. Leaf lesions with their papery centers and reddish-brown borders often reach a diameter of ½ inch or more. Infected leaflets may be killed by the disease. Infection of the seed head results in a shriveling and shelling of the fruits.

Roots previously injured in some manner may be attacked by the disease with the formation of a dry, brown rot. The spores, which are formed principally on stem lesions, are spread about the garden by wind and dashing rains. About 24 hours of moist conditions are required for spore germination and tissue penetration. New lesions appear about 7 to 10 days after infection. The disease overwinters principally in a dormant, vegetative condition in diseased ginseng tissue. Growth renewal, quickly followed by spore production, occurs in the early spring, and, as a result, the fungus is ready to cause infection of the young ginseng shoots as they come through the ground.

Thorough destruction of the diseased tops in the late fall by burning or other comparable methods is one means of keeping the disease in check. Bordeaux mixture has been recommended as a spray for the control of the disease for many years, but many Ohio growers have failed to make the best use of it and, as a result, whole plantings have been defoliated by *Alternaria* blight.

During the past 5 years a variety of sprays and dusts has been used by the authors on ginseng for the control of this disease. These have included such materials as a 3-4½-50 bordeaux mixture used alone and in combination with various stickers, spreaders, and arsenical compounds. Also, sprays containing colloidal copper or colloidal sulfur, as well as a monohydrated copper-hydrated lime dust, were used. The experiments were carried on in two different woodlot plantings near Wooster, Ohio. A four-application spray schedule was followed each year as follows: When most of the plants had broken through the soil, when the leaves were fully expanded, just preceding bloom, and about 2 to 3 weeks after bloom (when the fruits were well formed).

A 20-80 copper-lime dust did not give control of *Alternaria* blight, principally because sufficient moisture was not usually present on the leaves to cause the formation of bordeaux mixture. None of the sprays containing copper or sulfur was effective in disease control, with the exception of bordeaux mixture and Pyrox. Bordeaux mixture, used alone, gave very satisfactory control of the disease in 3 of the 4 years during which it was used. The addition of soap made the spray easier to apply without materially increasing its efficiency in disease control. The further addition of arsenates increased the fungicidal efficiency of the resulting mixture over bordeaux mixture alone. Pyrox (a proprietary bordeaux containing arsenates) was not significantly better than bordeaux mixture used alone or with soap. From the standpoint both of cost of the material and of its efficiency in controlling disease, the use of a 3-4½-50 bordeaux mixture, to which 1 pound of both potash fish-oil soap and calcium arsenate have been added for each 50 gallons of spray material, is recommended by the authors for the control of *Alternaria* blight of ginseng.

The yields of roots from the variously treated beds, which it was hoped would be of aid in evaluating the effect of the different treatments, were found to have been so affected by inroads of black rot and by unequal drouth effects on the plants in the differently treated beds that the data were not considered.

Bordeaux mixture may cause three different types of injury when applied to ginseng plants: (1) Leaf burning by improperly prepared material; (2) cold weather-bordeaux injury in which the wet tissue of young leaves is frozen during periods of low temperature, resulting in leaf killing or, if the injury is not that severe, in later growth deformation involving margin shredding; (3) a combination of drouth and bordeaux injury in which the leaves of

plants suffering from a lack of soil moisture are so severely desiccated by the drying influence of the spray that marginal injury or death of whole leaflets may result. Complete defoliation of the plants often follows.

This bordeaux-drouth type of injury occurred during 3 of the 5 years during which the experiments dealt with in this bulletin were in progress. It was very serious in woodlot plantings in the severe drouth year of 1930 and was also present in 1931 and 1932. The plants in nearby beds which did not receive a bordeaux mixture spray did not die from these drouth effects, even in 1930. Soil-moisture determinations made in 1931 indicated that the critical soil-moisture content at which drouth injury became apparent on the leaves of plants sprayed with bordeaux mixture was between 12.0 and 17.5 per cent, computed on the basis of the dry weight of the soil. In 1932 it was found that, when plants just beginning to wilt because of a deficiency of soil moisture were sprayed with bordeaux mixture, death of the leaves from drying out followed within 24 hours. If artificial irrigation is not available, it seems advisable to postpone spraying of ginseng grown in woodlots during drouth periods until after the occurrence of a rain sufficiently heavy to wet the soil of the beds thoroughly.

The authors wish to acknowledge their indebtedness to Messrs. Swan, Meese, and Grolle, of Wilmot, Ohio, and to Mr. Mullett, of Orrville, Ohio, for their hearty cooperation in carrying on the experimental work described in this bulletin.

LITERATURE CITED

1. Runnels, H. A. and J. D. Wilson. 1932. Ginseng spraying experiments. Ohio Agr. Exp. Sta. 50th Ann. Rept., Bull. 497, 59-60.
2. Stockberger, W. W. 1921. Ginseng culture. U. S. Dept. Agr., Farmers' Bull. 1184, 1-12.
3. Whetzel, H. H. 1907. Bordeaux cold injury of ginseng during the spring of 1907. Special Crops, n. s., 6: 184-187.
4. ———, S. E. A. McCallan, and T. C. Loh. 1929. Calcium arsenate as a fungicide. Phytopath. 19: 83.
5. ——— and J. Rosenbaum. 1912. The diseases of ginseng and their control. U. S. Dept. Agr., Bur. Pl. Indus. Bull. 250, 1-44.
6. ———, ———, J. W. Brann, and J. A. McClintock. 1916. Ginseng diseases and their control. U. S. Dept. Agr., Farmers' Bull. 736, 1-20.
7. Wilson, J. D. and H. A. Runnels. 1930. Ginseng blight control. Ohio Agr. Exp. Sta. 48th Ann. Rept., Bull. 446, 73.
8. ——— and ———. 1930. Alternaria blight of ginseng, preliminary experiments in the control. Ohio Agr. Exp. Sta. Bimo. Bull. 142, 11-14.
9. ——— and ———. 1931. Bordeaux mixture as a factor increasing drouth injury. Phytopath. 21: 729-738.
10. ——— and ———. 1933. Some detrimental effects of spraying tomatoes. Ohio Agr. Exp. Sta. Bimo. Bull. 18: 4-15.

This page intentionally blank.

This page intentionally blank.